

U.S. Patent Application Serial No. 10/735,886
Response filed April 29, 2005
Reply to OA dated January 14, 2005

REMARKS

Claims 1, 5 and 18 have been amended in order to more particularly point out, and distinctly claim the subject matter to which the applicants regard as their invention. The applicants respectfully submit that no new matter has been added. It is believed that this Amendment is fully responsive to the Office Action dated January 14, 2005.

Claims 1 - 6 and 18 are currently pending in this patent application as a result of the Response to Restriction Requirement filed November 9, 2004.

Claims 1 - 4, 6 and 18 stand rejected under 35 USC §102(e) based on Takata (U.S. Patent No. 6,500,675). The applicants respectfully request reconsideration of this rejection.

The applicants respectfully submit that is the object of the present invention to eliminate, in a multilayer interconnection structure in which a copper interconnection layer and an upper level interconnection layer are connected with each other via a minute contact hole formed in an interlayer insulation film interposed between the copper interconnection layer and the upper interconnection layer, the problem of corrosion caused in the barrier metal film surrounding the tungsten plug formed in the foregoing minute contact hole or the problem of corrosion caused in the copper

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interconnection layer, as set forth in lines 25 - 35, page 5 of the applicants' specification. Further, as set forth in page 5, line 32 through page 6, line 3 of the applicants' specification, this problem appears conspicuous when the aspect ratio of the via-hole has exceeded 1.25.

Takata, on the other hand, merely teaches a multilayer interconnection structure, wherein Takata refers to the possibility of using a nitride for a barrier metal in a general representation in column 9, lines 6 - 7.

However, Takata fails to teach the use of the specific aspect ratio of 1.25 or more recited in claim 1. Further, Takata is silent about the specific construction of the present invention of "said conductive nitride film is defined by an inner wall contracting with said outer wall of said tungsten plug and an outer wall contacting with said inner wall of said via-hole." While it is known that a metal nitride can be used for the barrier metal, such a metal nitride is generally laminated with a metal film with such conventional multilayer interconnection structure.

Also, as discussed in line 32, page 5 through line 18, page 6 of the applicants' specification, in response to the problems encountered by the conventional multilayer interconnection structure, when a defect occurs in a sidewall surface of a via-plug or in a contact part of a copper interconnection pattern contacting with the via-plug due to such corrosion, "not only the contact resistance is increased but also the resistance to the electromigration or stress migration is

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deteriorated, and the yield and reliability of the semiconductor device is degraded seriously.”

The mechanism in the formation of the defects 11X and 12X, as shown in the applicants' FIGS.3A and 3B, are discussed in line 26, page 11 through line 13, page 12 of the applicants' specification.

Further, as specifically discussed in lines 8 - 13, page 12 of the applicants' specification that:

the defect 11X occurring in the copper interconnection pattern 11Cu is caused also as a result of reaction of the gaseous source of tungsten such as WF₆ with the copper interconnection pattern 11Cu via the cavity thus formed in the barrier metal.

Accordingly, in the applicants' invention, a barrier metal film covering the minute via-hole is formed solely by a conductive nitride film. Thus, the problem with respect to the occurrence of corrosion reaction of the barrier metal film caused at the time of filling the via-hole by a CVD process of tungsten by the CVD source gas is solved by the claimed invention.^{1/}

In the Examiner's reliance on Takata, the Examiner specifically relies on Takata's metal layer 9b for teaching the applicants' claimed first interconnection layer.^{2/} Moreover, the Examiner

^{1/} See, line 26, page 11 through line 13, page 12, and the paragraph bridging pages 12 and 13 of the applicants' specification.

^{2/} See, lines 6 and 7, item 3, page 2 of the outstanding Action. Also, please see, the Examiner's reliance on Takata's Figure 6.

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specifically relies on Takata's metal layer 12b for teaching the applicants' claimed conductive nitride film.^{2/} Moreover, the Examiner specifically relies on Takata's following discussions in lines 49 - 54, column 9 in support of his contention that Takata's metal layer or second layer 12b teaches the applicants' claimed conductive nitride film:

[m]etal plug portion 12A has, like metal plug 8, first layer 12a and second layer 12b. First layer 12a includes a high melting point metal such as Ti, Ta, W, Mo, or Hf, nitride or silicate thereof, or a stack of these materials. Second layer 12b includes W, Ti, TiN, Cu, Al, AlSi, or AlCu.

It is noted that although Takata's second layer 12b may include titanium nitride (TiN) (i.e., nitride film), Takata's metal layer 9b (said to teach the applicants' claimed first interconnection layer) does not contact Takata's second layer 2b (said to teach the applicants' claimed conductive nitride film). Further, Takata is not concerned with the corrosion of metal layer 9b.

As discussed above, the applicants' barrier metal film 12A prevents not only the corrosion 12X from occurring in the Ta film 12b, but also prevents corrosion 11X from occurring in the copper interconnection pattern 11Cu.

As such, the applicants have amended each of independent claims 1 and 18 in order to more positively recite the claimed conductive nitride film, and more particularly recite in each of such claims

^{2/} Please, lines 13 - 16, page 3 of the outstanding Action.

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that the claimed conductive nitride film contacts the claimed first interconnection layer.

In view of the above, not all of the claimed elements, as now set forth in the amended claims, are found in exactly the same situation and united in the same way to perform the identical function in Takata's device. Thus, there can be no anticipation of the applicants' claimed invention based on the teachings of Takata.

Accordingly, the withdrawal of the outstanding rejection under 35 USC §102(e) based on Takata (U.S. Patent No. 6,500,675) is in order, and is therefore respectfully solicited.

Claims 5 stands rejected under 35 USC §103(a) based on Takata in view of Brown (U.S. Patent No. 6,306,732). The applicants respectfully request reconsideration of this rejection.

The applicants have attained for the first time the knowledge, resulting in the claimed invention, concerning the corrosion of the barrier metal film caused by the F-containing gas such as WF₆ in a minute contact hole having the aspect ratio of 1.25 or larger. As such, there is no motivation to a person of ordinary skill in the art to modify the teachings of Takata in order to provide the barrier metal of nitride in a via-hole having the aspect ratio of 1.25 or more, such that said conductive nitride film is defined by an inner wall contracting with said outer wall of said tungsten plug and an outer wall contacting with said inner wall of said via-hole.

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It is noted that the Examiner is of the opinion that Takata teaches the use of the aspect ratio of 2.0. However, with due respect to the Examiner, no such mention has been found in the Takata patent.

It is respectfully noted that the Examiner specifically relies on Brown for teaching a multi-layer stack of barrier layers having the characteristics set forth, according to the Examiner, in lines 6 - 12, item 5, page 4 of the outstanding Action.

However, the secondary reference of Brown does not supplement the above-discussed deficiencies or drawbacks in the teachings of the primary reference of Takata in failing to fully meet the applicants' claimed multi-layer interconnection structure, as now set forth in independent claim 1 (from which claim 5 depends), in which the claimed conductive nitride film contacts the claimed first interconnection layer.

Also, with respect to claim 5, the applicants have, in any event, amended claim 5 so as to more positively recite the structural arrangement of the claimed nitride film.

In view of the above, the withdrawal of the outstanding obviousness rejection under 35 USC §103(a) based on Takata in view of Brown (U.S. Patent No. 6,306,732) is in order, and is therefore respectfully solicited.

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In view of the aforementioned amendments and accompanying remarks, claims, as amended, are in condition for allowance, which action, at an early date, is requested.

If, for any reason, it is felt that this application is not now in condition for allowance, the Examiner is requested to contact the applicants' undersigned attorney at the telephone number indicated below to arrange for an interview to expedite the disposition of this case.

In the event that this paper is not timely filed, the applicants respectfully petition for an appropriate extension of time. Please charge any fees for such an extension of time and any other fees which may be due with respect to this paper, to Deposit Account No. 01-2340.

Respectfully submitted,

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